1.4. SOUTH POLE OBSERVATORY

D. NEFF, P. ROBERTS, A. CLARKE, J. MICHALSKI,
E. SANDBERG, AND B. HALTER

1.4.1. OPERATIONS

The CMDL South Pole Observatory (SPO) is located at the geographic south pole on the Antarctic plateau at an elevation of 2838 m above sea level. The majority of CMDL SPO projects are housed within the Atmospheric Research Observatory (ARO), a National Science Foundation (NSF) facility that is used in support of scientific research related to atmospheric phenomena and is part of the overall Amundsen-Scott South Pole Station. The CMDL SPO projects were previously located at the now demolished Clean Air Facility (CAF), and the CMDL observatory at ARO is still often referred to as the CAF.

Amundsen-Scott South Pole Station is an integral part of the U.S. Antarctic Program (USAP), which is funded and managed by NSF. Most of the administrative, logistical, and operational support for USAP is provided by private business under contract to NSF. The current prime support contractor is Raytheon Polar Services (RPS). Antarctic Support Associates (ASA) was the prime contractor from April 1990 through March 2000.

The ARO facility is located approximately 500 m grid east-northeast of the new elevated station, physically separated and generally upwind of all other station facilities. (Grid north, grid $0^o/360^o$, is defined as parallel to and in the direction of the prime meridian from the South Pole; Greenwich is situated grid north of South Pole Station.) The ARO building is located at the vertex of an obtuse angle, with sides aligned to grid 340^o and grid 110^o, which define the Clean Air Sector (CAS). The prevailing winds at South Pole are from the CAS more than 90% of the time.

The CAS was established to preserve the unique atmospheric and terrestrial conditions from South Pole Station influences. Except for special circumstances, access to the CAS is prohibited, allowing for nearly continuous measurement of trace constituents of the atmosphere in a location remote from anthropogenic sources and sinks.

CMDL's stratospheric ozonesonde program is conducted from the Balloon Inflation Facility (BIF), which is located grid south (generally downwind) of the new elevated station. This facility is shared with the RPS meteorology staff and occasionally with other research groups.

There are, for practical purposes, two distinct "seasons" at South Pole Station. The austral summer season (November through January) and the austral winter season (February through October). Current staffing at the station exceeds 200 persons during the summer season and is reduced to approximately 50 "winterovers" during the winter season.

The only USAP transportation to and from South Pole Station is on one of more than 300 "routine" Lockheed Martin LC-130 Hercules aircraft flights during the austral summer season. These flights, currently flown by the 109^{th} Airlift Wing of the New York Air National Guard, typically take place from late October to mid-February (station opening to station closing) each year. Occasional USAP-contracted de Havilland DH-6 Twin Otter aircraft flights are made to the station, mostly using South Pole as a stopover during special programs.

South Pole Station, including CMDL's observatory, is physically isolated from the rest of the world during the austral winter season. During this period, temperatures are generally too low, the weather too unpredictable, and the risk to hydraulic systems too great for aircraft to operate safely. An unprecedented Twin Otter "medevac" flight was made to the station in April 2001, but this capability cannot be relied on in general.

Due to the 9-mo isolation, air samples taken during the austral winter cannot be returned for analysis until the station reopens the following November. However, communications and data access via satellite (including Internet connectivity) are available for several hours each day throughout the year. Data collected in situ are transmitted regularly via the Internet to locations around the world.

During the austral summer season the CAF usually receives a large number of Distinguished Visitors (DVs). Typical DVs are members of Congress and their staff, U.S. and N.Z. Embassy officials, U.S. military delegations, U.S. Executive Branch delegations, members of the National Science Board, ex-astronauts, and members of numerous news organizations.

The summer season at South Pole Station is marked by a variety of activities, relatively "warm" temperatures (about –30ºC average and sometimes as warm as –15ºC), and constant sunlight. The average temperature during the winter season is about –60ºC, but temperatures can drop below –75ºC on occasion. The Sun sets toward the latter part of mid-March, twilight is generally significant through the middle of April, and the winter night begins in earnest toward the end of April. The first faint signs of light from the Sun are clearly visible again in early August, preceding sunrise in the latter part of mid-September. Station life generally runs at a slower pace during the winter season.

ARO Electrical

South Pole Station power is generally reliable, but outages and other problems occasionally do occur. ARO and BIF are equipped with uninterruptable power supplies (UPS) for some of the more sensitive equipment. However, in recent seasons, the buildings' UPS systems have not been reliable, and individual UPS systems have been installed for most of the CMDL experiments.

The ARO first-floor UPS system failed in December 2000. A replacement was installed within 2 months, but it also failed prior to carrying an electrical load. Several smaller UPS systems were shipped from CMDL in the interim while NSF and Raytheon worked to provide generalized UPS systems for ARO. The ARO second-floor UPS system has been inoperable for several seasons and continues to be unusable. A 30-kVA transformer was installed in February 2001 within ARO to supply power to temporary buildings occupied throughout the year by other atmospheric scientists.

Station Network/Communications

Voice and Internet access to/from South Pole Station are available for several hours each "day" dependent on satellite coverage, equipment, and weather. Detailed technical information is provided on the RPS website (www. rpsc.raytheon.com) and on the NSF website (www.nsf.gov). The ARO Local Area Network (LAN) is connected to the station-wide system, which is managed by RPS for NSF. Selected ARO computers are connected to this system for remote login and data retrieval. CMDL data retrieval is conducted through satellite connections, when available.

Outreach

Unofficial visitors at South Pole Station are rare, but outreach is possible through Internet connections and to some extent through the mail. School groups frequently write, curious about the lifestyle and the science at the station.

The number of visitors (official USAP and "non-governmental") on record at ARO for the three reported seasons are 20 for the 1999 season, 57 for the 2000 season, and 40 for the 2001 season.

The actual numbers are slightly higher, because visitors occasionally slip through without signing the CMDL guest book.

1.4.2. PROGRAMS

Table 1.4 summarizes the programs at SPO for 2000 and 2001 austral seasons. Operational highlights follow for the 1999, 2000, and 2001 seasons. Items mentioned refer to all three seasons except where otherwise noted. For specific operational details, refer to the monthly SPO station reports and the individual equipment checksheets and digital logs available from the CMDL Observatory Operations office.

Gases

Carbon Cycle. The Siemens continuous carbon dioxide analyzer ran with very few significant problems. The analyzer's chopper lamp was replaced with a "mini-maglite" lamp from early March to late October 2000 in lieu of a standard spare. The zero-gas flow was reduced in early April 2000 to conserve the supply, and old working-gas cylinders were used in lieu of zero gas from early May 2000 onward. In November 2000 the mini-maglite lamp was replaced with a new chopper lamp. The Siemens analyzer began to develop intermittent noise problems and voltage fluctuations early in 2001 and was replaced with a new LI-COR system at that time.

Sample flasks were filled through the analyzer twice per month during the 1999 and 2001 seasons and once per week during the 2000 season. Flasks were also filled once per week with the Martin and Kitzis Sampler (MAKS) portable pump unit. An external 12-V battery was connected to the MAKS unit in May 1999 to replace the standard internal battery that had failed.

Ozone and water vapor. The Dasibi surface ozone analyzer operated continuously with no significant problems during the reported seasons. A second analyzer, manufactured by Thermo Environmental Instruments (TEI), was installed in December 1999 and operated well. Preliminary results indicate the two instruments showed close agreement through the 2001 season.

Routine measurements of total column ozone were taken three times daily during the austral summer months with a Dobson total ozone spectrophotometer. Whenever possible, total ozone values were obtained in the austral winter with the Dobson and the full moon as the light source.

The balloonborne stratospheric ozonesonde program continued to run well. During the annual austral spring/ early summer stratospheric ozone depletion, ozone profiles up to about 30 km were obtained about three times per week and up to once per day during the total ozone minimum. Profiles were obtained once per week during the remainder of the year. Several special ozonesonde intercomparison flights were completed in January 1999. These flights were part of a larger ozondesonde intercomparison program.

Halocarbons and other atmospheric trace species. The custom-built Chromatograph for Atmospheric Trace Species (CATS) gas chromatograph (GC) and the existing Radiatively Important Trace Species (RITS) GCs were operated side by side throughout the 1999 and 2000 seasons. All instrumentation operated continuously except for the occasional repair or replacement of failed components. Routine maintenance and gas cylinder replacements caused very few interruptions of GC measurements. Ultra-high purity (UHP) air was used in lieu of calibration (CAL 1) gas from early November 1999 until the new CAL 1 cylinder arrived in the middle of February 2000. The RITS GCs were removed, and the CATS gas select valves were replaced in December 2000.

Sample flasks were filled twice per month with the Halocarbons and other Atmospheric Trace Species (HATS) group flask pump. In addition, during austral winter 2000, glass flasks were filled once per month to be compared with the typical samples collected in stainless-steel flasks. Some species can be analyzed from air samples stored in glass flasks that cannot be measured reliably from air stored in stainless-steel flasks.

Aerosols

The four-wavelength nephelometer suffered through a spate of problematic filter wheel motors, and except for the replacement of an electronics board and consequent reference calibrations, the instrument operated without major problems during the 1999 season. The nephelometer operated continuously with no significant problems during the entire 2000 season. During the 2001 season the nephelometer was again problematic, and data collection was intermittent for most of the season even after extensive repairs. Routine condensation nuclei (CN) measurements were carried out both seasons with the Pollak instrument.

The Thermo Systems Incorporated (TSI) CN counter (CNC) operated with no major problems during the 1999 season although several minor repairs were necessary. The TSI CNC operated continuously with no significant problems during the entire 2000 season. A replacement TSI output module board was installed in May 2001 to address discrepancies found between the TSI CNC front-panel readout and the corresponding value recorded by the Campbell Scientific Inc. (CSI) acquisition module.

TABLE 1.4. Summary of Measurement Programs at SPO in 2000 and 2001 Austral Seasons

Program/Measurement	Instrument	Sampling Frequency
Gases		
CO_2	Siemens non-dispersive IR analyzer (ended 2001)	Continuous
	LI-COR system (began 2001)	Continuous
CO_2, CH_4, CO, H_2, N_2O, SF_6, $^{13}C/^{12}C$ of CH_4, and $^{13}C/^{12}C$, $^{18}O/^{16}O$ of CO_2	2.5-L glass flasks, through analyzer	1 pair wk^{-1} (2 mo^{-1} in 2001)
	2.5-L glass flasks, MAKS pump unit	1 pair wk^{-1}
Surface O_3	Dasibi and TEI surface ozone analyzers	Continuous
Total column O_3	Dobson spectrophotometer no. 80	3 sets day^{-1}
Ozone vertical profiles	Balloonborne ECC sonde	~3 wk^{-1}, spring/early summer; ~1 wk^{-1}, remainder of year
CFC-11, CFC-12, CFC-113, HCFC-21, HCFC-22, HCFC-124, HCFC-141b, HCFC-142b, HFC-134a, HFC-152a, H-1211, H-1301, CH_3Cl, CH_2Cl_2, $CHCl_3$, CCl_4, CH_3CCl_3, C_2Cl_4, CH_3Br, CH_2Br_2, $CHBr_3$, CH_3I, N_2O, SF_6, COS, C_6H_6	0.85-L, 2.5-L, or 3.0-L stainless-steel flasks	2 pair mo^{-1} (~1st and 15th)
	2.5-L glass flasks, pump unit	1 pair mo^{-1} (~15th)
CFC-11, CFC-12, CCl_4, CH_3CCl_3, N_2O	Two RITS Shimadzu GCs (ended 12/00)	1 sample h^{-1}
CFC-11, CFC-12, CFC-113, HCFC-22, HCFC-142b, H-1211, CH_3Cl, $CHCl_3$, CCl_4, CH_3CCl_3, CH_3Br, N_2O, SF_6, COS	Automated CATS GC	1 sample h^{-1}
Aerosols		
Condensation nuclei	Pollak CNC	2 set day^{-1}
	TSI CNC	Continuous
Optical properties	Four-wavelength nephelometer	Continuous
Solar Radiation		
Global (total) irradiance	Eppley pyranometer with Q filter	Continuous, summer
	Eppley pyranometer with RG8 filter	Continuous, summer
Direct irradiance	Eppley pyrheliometer with Q and RG8 filters (tracking NIP)	Continuous, summer
	Eppley pyrheliometer with Q, OG1, RG2, and RG8 filters (manual filter-wheel NIP)	~3 sets day^{-1}, summer
Diffuse irradiance	Eppley pyranometer with shading disk and Q filter	Continuous, summer
Albedo	Eppley pyranometer with Q filter (downward facing)	Continuous, summer
	Eppley pyranometer with RG8 filter (downward facing)	Continuous, summer
	Eppley pyranometer with Q filter (on tower/downward facing)	Continuous, summer
Optical depth	SP01-A multiwavelength aureole sunphotometer	Continuous, summer
Terrestrial (IR) Radiation		
Upwelling and downwelling	Two Eppley pyrgeometers	Continuous
Meteorology		
Air temperature (2- and 20-m heights)	Logan platinum resistance probe	Continuous
Pressure	Setra capacitive pressure transducer	Continuous
	Mercurial barometer	1 wk^{-1}
Wind (speed and direction at 10-m height)	R.M. Young wind monitor	Continuous
Frost-point temperature	TSL dewpoint hygrothermometer	Continuous
Cooperative Programs		
CO_2, ^{13}C, N_2O (SIO)	5-L evacuated glass flasks	2 trios mo^{-1} (~1st and 15th)
O_2/N_2, CO_2 (SIO)	Pump unit, 5-L glass flasks	2 trios mo^{-1} (~1st and 15th)
Surface Air Sampling Program (DOE/EML) (natural and anthropogenic radionuclides)	High-volume pump and filters	Continuous (4 filters mo^{-1})
Interhemispheric $^{13}C/^{12}C$ (CSIRO) (CO_2, CH_4, CO, H_2, N_2O, and $^{13}C/^{12}C$, $^{18}O/^{16}O$ of CO_2)	Pump unit, 0.5-L and 5-L flasks	2 pairs mo^{-1} (~1st and 15th)
H_2O_2 (Univ. of Arizona)	Surface snow sample collection	2 wk^{-1}
TFA (Univ. of Arizona)	Surface snow sample collection (2001 only)	1 mo^{-1}
Oxygen isotopes (UCSD)	High-volume pump and filters (2001 only)	Continuous (1 wk^{-1})
Sulfur compounds (ISCAT)	High-volume pump and filters	Continuous (1 mo^{-1})
	1-L flasks (2001 only)	Periodically

Solar and Terrestrial Radiation

The instrumentation ran with no significant problems during the reported seasons, though occasional noise in the signal lines remained an issue. The majority of instrumentation is disconnected during the winter months, May to September, but the terrestrial radiation instruments are typically left operational year-round. The instrumentation was connected to a single-point electrical ground during the 2001 season to address problems with noise pickup.

The albedo rack was raised in December 1999. A new precision spectral pyranometer (PSP) was installed on a boom suspended from the NOAA meteorology tower in January 1999. Several scheduled instrument replacements were made during austral summers 1999-2001. The SP01-A aureole sunphotometer was operated at SPO from late December 1999 to late January 2000, from mid-November 2000 to late March 2001, and again from late September 2001 through mid-November 2001.

Meteorology

The meteorology instrumentation operated continuously with no significant problems. Daily weather observations were recorded, and special observations were taken, when possible, if conditions changed significantly.

The temperature and wind sensors on the tower were raised in early February 2000 and again in February 2001 to maintain the WMO-recommended height specifications above the ever-rising snow surface. The sensors were calibrated and inspected during the February 2000 maintenance.

Cooperative Programs

Scripps Institution of Oceanography (SIO). Sample flasks were filled twice per month for later analysis at SIO.

U.S. Department of Energy/Environmental Measurements Laboratory (DOE/EML). The Surface Air Sampling Program (SASP) pump ran continuously without significant problems. Sample filters were changed once per week, and a sample blank was collected monthly.

Commonwealth Scientific and Industrial Research Organization (CSIRO). Sample flasks were filled twice per month for later analysis by CSIRO.

University of Arizona. Snow samples were obtained and snow heights were measured from a "sampling grid" inside the Clean Air Sector weekly during the 1999 season. Groups of surface snow samples were obtained approximately seven times each month during the 2000 and 2001 seasons. Snow samples were also collected monthly during the 2001 season for trifluoroacetate analysis.

University of California, San Diego (UCSD). Weekly rooftop filter samples were collected during the 2001 season beginning in February 2001.

Investigation of Sulfur Chemistry in the Antarctic Troposphere (ISCAT). Forty-eight air samples were collected in metal sampling cans periodically throughout the 2001 season. Rooftop filter samples were collected weekly until February 2001. A significant number of air samples were also collected during the 1999 and 2000 seasons, though no filter samples were collected then.